U.S. GRAIN MARKETING RESEARCH LABORATORY

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PREFACE

This summary report reviews activities and accomplishments of the U.S. Grain Marketing Research Laboratory (USGMRL) in FY 1979. Like the previous reports, it concentrates on what happened during the past year. It has been a year of redirecting some of our resources that strengthened our programs in line with our objectives to maintain a viable and balanced program. The redirection has made possible good use of our two strongest assets: (1) the availability, under one roof, of human and physical resources for interdisciplinary research, and (2) the recognition that long-range basic and applied research, responsive to immediate needs, are companions for successful and valuable research. We have found that the time-proven route from new concepts through applied investigations in the laboratory, pilot plant, and field to development of new products or methods is still the best return on the taxpayers' investment in research. Some of our studies were conducted in cooperation with scientists in other U.S. Department of Agriculture (USDA) agricultural research facilities and in several universities. Most of our collaborative studies were with researchers at the Kansas Agricultural Experiment Station and represented effective and mutually beneficial cooperative efforts.

An increasing number of projects involved cooperation with several action-regulatory agencies in USDA: the Federal Grain Inspection Service, Agricultural Marketing Service, Animal and Plant Health Inspection Service, and the Foreign Agricultural Service. The facts and accomplishments speak for themselves. They are given in the list of publications and oral presentations and are highlighted in this preface.

We have completed the first comprehensive study on the fine structure of the oat kernel and endosperm and its starch granules and protein bodies. The mechanism and nature of protein bodies and their formation in cereal grains were studied. The colorimetric alpha-amylase test for sprout damage in wheat was studied by 23 collaborators from 10 countries and was shown to be sensitive and highly correlated with falling number and amylograph viscometric methods. The colorimetric test has been simplified and shortened and developed into a procedure for rapid screening of wheat and other cereal grains in marketing channels. The procedure has been standardized by using basic laboratory equipment, the total cost of which is about $1,500. The procedure is sufficiently simple for use by untrained personnel in a grain elevator. Ergosterol used in determining incipient deterioration of cereal grains damaged by molds in storage is being evaluated on a pilot-plant scale. Protein content, amino acid composition, and chemical scores continue to be used to evaluate the nutritional value of corn proteins in corn selections, crosses, and cultivars.

We found that in wheat flour containing no nonpolar lipids, loaf volume potential was governed by the quantity of polar lipids, shortening, and interaction of shortening and polar lipids. To bring out the maximum loaf volume potential of flours, we have shown that the multiple interaction of proteins with free polar lipids and with protein, in the presence of shortening, seems to be superior to the mere formation of protein-protein aggregates. Based on these and related studies, we have established conditions for determining genetic differences in breadmaking quality as affected by lipid contents and composition. Preliminary studies related loaf volume potential to polar lipids, ratio of nonpolar to polar lipids, or galactose in lipid extracts. The highly significant correlations are potentially useful to predict, in combination with total protein content, loaf volume potential of hard red winter (HRW) wheats or flours.

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Resuming U.S. hay exports to Japan was made possible by a quarantine fumigation and certification procedure developed to provide control of potential contamination of the hay by Hessian fly. Field experiments suggested that temperature is the limiting factor in *Aspergillus flavus* infection and in aflatoxin production in corn in the field. An extensive survey of infestation in exported corn and wheat was conducted. Production of significant amounts of potentially explosive dust by the rice weevil and the lesser grain borer was documented. Studies in our laboratories have shown that *Bacillus thuringiensis* can be effective against moth infestations, and that it is compatible with some fumigants that are used to control pests in stored grains. Six years of research on an alternative to chemical insecticides for preventing insect damage to stored grain culminated with registration by the Environmental Protection Agency of the first microbial insecticide, from *B. thuringiensis,* formulation for moth control in stored grains and soybeans.

A new amino acid metabolite, tyrosine glucoside, has been identified in insects. A new peptide, identified in the insect gastrointestinal tract, is structurally related to vertebrate glucagon. Several insect growth regulators that inhibit cuticle carbohydrate metabolism were found to be effective population suppressants for beetles and moths in stored grain. An insecticidal toxin from the parasporal crystal of *B. thuringiensis* was purified and identified for the first time. The toxin, which is generated upon solubilization and activation of a higher molecular weight protein ($MW_{app} = 1.3 \times 10^5$) at alkaline pH, and is stable for several months, is a glycoprotein with an apparent molecular weight of 68,000.

The main effort in the Engineering Unit has been to conduct research on 25 projects relating to grain dust—its characteristics, explosibility, hazard control, monitoring, and utilization. As little as 0.02 percent soybean or mineral oil significantly reduced the dustiness of corn and wheat and remained effective for up to 6 months. There was no measurable effect of the oils on the milling or baking quality of wheat. We developed two methods for measuring dust concentration in air and evaluated a commercial device to reduce dust in the air during unloading of grain. Two methods of utilizing dust—as a fuel or as a soil conditioner or organic fertilizer, or both—were investigated. Economic assessment of dust pelleting and extrusion was completed by an Economics, Statistics, and Cooperatives Service employee at USGMRL. A breakage test was standardized that measures the susceptibility of corn and soybeans to breakage during handling.

Other engineering work involved a simulation study of corn production and low temperature drying using two computer models. One simulates the cropping system from planting through harvest; the other receives simulated harvest data and carries the crop through drying and storage.

Functional (milling and baking) properties of over 2,200 HRW wheat selections were evaluated. We are proud to be part and one of the focal points of a regional breeding program for the major wheat crop that resulted in producing higher yielding cultivars with increased protein contents. A liquid chromatographic analysis of coumestrol in germinated soybeans and flours therefrom was conducted, and an improved method for extracting and quantitating coumestrol was developed. An ion-exchange chromatography routine method for determining hexosamines in fungal chitin was published. We studied the functional (breadmaking) properties of wheat protein fractions obtained by ultracentrifugation and determined the physical and biochemical properties of those wheat protein fractions. A comprehensive study was conducted on alpha-amylase in field-sprouted wheats and its distribution and effect on baking and related physical and chemical properties. Means of counteracting the deleterious effects in breadmaking of high levels of fiber-rich additives were investigated.

We are especially concerned about insect infestation problems in the 6.7 billion bushels of farm-stored grain and the increasing demands for high quality grain both in domestic and foreign markets. Thus, we organized a 3-day conference April 9 to 11, 1979, for extension entomologists on "Pest Management in Farm-Stored Grain." The conference was sponsored by USGMRL in cooperation with the Kansas State University Departments of Entomology and Grain Science and Industry. Forty extension entomologists from 27 states attended the conference, which focused on practical applications of available technology.

In the summer of 1978, we envisioned holding a symposium on grain dust. We believed we had enough projects underway that we could, if necessary, fill a program by October 1979 with papers based on our own work at USGMRL. We were pleasantly surprised when an invitation for outside papers brought forth offers by researchers, engineers, and the grain trade from Australia, England, Japan, Poland, Switzerland, and the United States. The program included the following presentations or reports: 8 by employees of USGMRL, 5 from universities working under cooperative agreement contracts with USGMRL, 7 from universities working on their own projects, 3 from other government agencies, 10 from industrial companies, and 9 by individuals from other research organizations. The 577 who attended the symposium came from 19 countries.

During the symposium, committee reports from the following organizations were presented: American Society for Testing and Materials, American Society of Agricultural Engineers, National Grain and Feed Association (Elevator Design), and National Research Council (USA) Panel on Causes and Prevention of Grain Elevator Explosions. The Symposium, organized by USGMRL, was cosponsored by USDA's Science and Education Administration and Federal Grain Inspection Service, Grain Elevator and Processing Society, National Grain and Feed Association, and Kansas State University. The meeting was followed by a practical short-course by the Firefighters Association. The presentations, reports, round table discussion, and short-course will be included in proceedings of the Symposium to be published early in 1980. USGMRL scientists have published the first comprehensive review of literature related to engineering aspects of grain dust explosions and a translation from Polish of proceedings of a highly informative conference on explosibility of industrial dusts. Those and many other activities have made USGMRL a major center of research and a national focal point for information on all aspects of grain dust.

The value of our research depends on its acceptance by the target recipients. That acceptance involves an economic assessment of cost and impact. We are pleased to have the fine cooperation of the scientists from USDA's Economics, Statistics, and Cooperatives Service, located at USGMRL. Their continued evaluation of the economic feasibility of several of our programs adds an important dimension to our work.

We have been under increased pressure to expand our extension related activities. The foregoing is evidence that we recognize the need and are fully responsive to it. We stress the danger of overemphasizing extension at the expense of new information to extend. We must have a sustained generation of new and pragmatic know-how that can be extended into practical information and use.

The excellence of our scientists continues to be recognized by numerous invitations to present lectures, appointments to editorial boards, selections to organize national and international symposia, and appointments to act as scientific editors of prestigious series of advances. We are gratified by the great numbers of visitors to our laboratories. Distinguished visitors of varied scientific professions from 49 countries and from 38 states of the United States came to see our research facilities, to acquaint themselves with our activities, to share their thinking with us, and to consult with our scientists about novel approaches and new developments. Their stays ranged from a short visit to a year of research work. Those visits, along with innumerable requests for information, interviews, lectures, and participation on committees, acknowledge our diversified activities as a center of Grain Marketing Research.

Y. Pomeranz

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CONTENTS

GRAIN STRUCTURE AND COMPOSITION UNIT

Scientists in this unit conduct investigations to (1) identify composition of cereal grains in relation to storage, handling, utilization, and nutritional value; (2) determine relation of structure of cereal grains to storage, handling, and utilization; (3) determine use of enzymes in determining composition, structure, storability, and damage during handling of cereal grains; (4) identify, control, and eliminate mycotoxins from cereal grains; and (5) assay the protein content and biological value of cereal grains, in particular, maize and sorghum.

Grain Composition

In these studies, our approach is to determine protein, lipid, mineral, and carbohydrate contents and interaction products among grain components as they relate to storage, handling, utilization, and nutritional value. The studies are designed to provide information, on composition of cereal grains, to other units in the U.S. Grain Marketing Research Laboratory in investigating the effects of composition on handling, storage, end-uses, nutritional value, and development of quality tests. Examples of studies in this area include determination and characterization of lipids (including the role of lipids in breadmaking), interaction between lipids and proteins, and determination and characterization of proteins. The information has been used to develop nutritionally-improved consumer-acceptable baked products.

Grain Structure

We study cereal grains and products of their processing by microscopic methods—light and scanning and transmission electron microscopy. These studies are designed to correlate grain structure with market quality investigations conducted in other research units in the Laboratory. Examples of studies in this area include comprehensive investigations on the structure of cereal grains, changes in the structure of dough and bread, structure of dough and bread from flours varying in breadmaking quality, and relation of grain structure to handling (corn breakage), storage (damage by molds and insects), end-uses, nutritional value, and development of quality tests.

Use of Enzymes

Enzymes are used to determine composition (proteins, carbohydrates, lipids, glycolipids, lipoproteins, and glycoproteins) and nutritional value of cereal grains, including availability of nutrients and their modification during handling, storage, and processing. Enzyme activity is assayed to determine grain quality (at sprouting and deterioration during handling and storage). We design the studies to provide information on composition, as determined by enzymatic assays, and on levels of enzymes in cereal grains to other units at the Laboratory for determining soundness, characterization, and development of quality tests. Enzymes will be used to determine, selectively and specifically, trace amounts of nutrients or contaminants in mold, insect, or rodent infested grain. Examples of studies in this area include determining sprout damage and differences in alpha-amylase in sprouted wheats and malts from various classes and locations and developing a mobile unit for field determination of alpha-amylase.

Mycotoxins

In mycotoxin research, we develop analytical procedures, preferably suitable for use in grain marketing channels, for detecting specific fungal components as measures of extent of invasion, mycotoxins, and other fungal metabolites; and for identifying fungi-grain interrelationships that may regulate invasion of particular grain types, varieties, or hybrids by specific genera or species of fungi. The approach used in these studies is to apply optimized extraction and chromatographic techniques and to simplify and make more effective initial extraction, clean-up, and final detection steps. Metabolites are evaluated as measures of fungal invasion on grains and are compared with mycological and other tests such as discoloration, germination, fat acidity, and odors. Differences in susceptibility to invasion by fungi among grain types, varieties, or hybrids, especially sorghum, also are investigated.

Corn and Sorghum Quality

These studies are conducted to assay the protein contents and chemical score, based on amino acid

content, of corn and sorghum. In addition, laboratory scientists compare various methods for routine determination of protein contents and quality in samples from plant breeders and from commercial channels.

BIOLOGICAL RESEARCH UNIT

The Biological Research Unit is concerned with fundamental and applied biology of insects and microorganisms that infest stored grains and cereal products. Insects and microorganisms are the principal kinds of organisms that adversely affect grain quality. Insect and microbial activity in stored grains decrease germinability, discolor part or all of the seeds or kernels, cause weight loss, reduce nutritional value, produce heat, and increase moisture. The latter two factors, in turn, bring about physical, chemical, and physiological changes in the grain. Some insects feed on whole grain, others on broken kernels, thereby increasing the percentage of broken kernels and dockage. Some microorganisms produce toxins that are injurious to man and to domestic animals. Grain and cereal products are subject to insect and microbial infestation, damage, and contamination while in the marketing channels. The Federal Government, the food storage, transportation, and processing industries, and the consumer suffer large monetary losses from grain insects causing damage and downgrading and making the products unfit for human consumption. The presence of insects and the damage done by them affects us adversely in the highly competitive foreign market.

Another cause for concern in relation to foreign trade in grain is that pesticide and fumigant residues are receiving increasingly critical scrutiny in the European Common Market countries as well as in other parts of the world. These residues also are of concern for the domestic market. There is urgent need for more acceptable and effective methods for preventing insect damage and contamination during storage, handling, processing, packaging, transportation, and retail distribution. The need is critical for effective pesticides and application methods that can be used in our domestic and foreign markets without leaving objectionable residues. Even more desirable is the development of effective preventive and control measures using biological, physical, mechanical, or other nonchemical means that would reduce or completely eliminate the application of pesticidal chemicals.

The primary mission of the Biological Research Unit is to gain adequate knowledge of insects and microorganisms and their storage environment to develop appropriate techniques and methods of pest management under experimental and practical conditions. Research is divided into the following areas.

Insect Biochemistry and Physiology

Our research in this area is to study the growth and development of stored grain insects to determine unique biochemical and physiological processes that are potential targets for new insect control agents. This approach to insect control uses a class of insecticides called biorational because of their specificity to insects and because they exhibit little or no adverse effects on man, wildlife, domestic animals, and the ecosystem. The program includes basic research in insect biochemistry, endocrinology, and morphology, and applied research in developing biorational compounds that specifically inhibit particular aspects of an insect's physiological and behavioral processes. Compounds receiving special attention are insect growth regulators with hormonal activity such as juvenile and molting hormones, glucagon, and insulin, and those that interfere with exoskeleton production, energy metabolism, reproduction, and sensory perception. The susceptibility of strains of the confused flour beetle, red flour beetle, lesser grain borer, rice weevil, granary weevil, maize weevil, sawtoothed grain beetle, cigarette beetle, Indian meal moth, and navel orangeworm to these chemical agents is being investigated.

Pesticide Biochemistry

Studies are conducted to develop new insecticidal formulations from chemicals that exhibit low mammalian toxicity as substitutes for currently used approved chemicals. There are problems in retaining effective control of stored grain insects because some species are developing tolerance and resistance to present-day pesticides. Basic and applied research is directed toward establishing efficacy of new chemicals as grain protectants, residuals, and as vapor toxicants in addition to determining the concentration of residues remaining after application; measuring the response of insects to varying

amounts of insecticidal materials applied to grain during an extended time; and elucidating the mode of action of certain organophosphorus compounds in insects. The effects of these compounds on *de novo* protein and nucleic acid synthesis and other cellular metabolic functions are being investigated using cultured embryonic cells of the Indian meal moth.

Insect Pathology

Investigations include developing methods for using microbial insect pathogens to prevent and control insect infestations in stored grain and processed products. Basic and applied research entails studies of the structure, physiology, and mode of action of selected bacterial and viral insect pathogens; susceptibility of strains of the Indian meal moth and almond moth to *Bacillus thuringiensis* and granulosis virus, differential toxicity of *B. thuringiensis* isolates, and efficacy of commercial formulations of *B. thuringiensis;* structure, toxicity, and biosynthesis of the entomocidal protein of *B. thuringiensis;* and effects of commodity characteristics, storage environment, biology and behavior of the target insect species, development of resistance to pathogens, and interactions with unaffected insect species on the use of insect pathogens for stored grain insect control.

Pest Bionomics

Research in this area is conducted to determine the influence of inert atmospheres—produced by exothermic inert atmosphere generators—on toxicity, fecundity, fertility, and development of the major stored grain insects. Other studies include examining the influence of temperature and moisture on the response of insects to the atmospheres produced by an exothermic inert atmosphere generator; the effects of applying modified atmospheres to bulk stored commodity ecosystems including insect populations, functional and biochemical properties of the treated commodity, and fungistatic activity; and the current costs of conventional chemical treatment of grain compared to the costs of installing and operating exothermic inert atmosphere generators to control insects in bulk stored grain, in cooperation with Economics, Statistics, and Cooperatives Service.

This program also includes a study to identify biological problems, both insect and microbial, associated with environments that occur in transported grain and that contribute to physical losses, reduced quality, and increased transportation costs.

Genetic Resistance in Seeds

Basic and applied biology is under investigation with grains that exhibit preference, antibiosis, and tolerance to insects and microorganisms. Specific attention is given to naked and hulled barleys and to several wheat varieties that exhibit differences in their response to certain insects and fungi. For those grains found to be resistant, efforts are made to determine the site in the grain and the cause of resistance. Planned work will involve genetics of resistance, hybridization techniques to combine resistant genes in seeds with desirable agronomic characters, resistance tests in advanced generation hybrids, and evaluation of resistant grains in laboratory and field trials. Specific lines of work will include isolating, purifying, identifying, and evaluating chemical constituents of grains that repel or attract insects and microorganisms and determining genetically controlled structural and morphological characteristics of resistant grain varieties.

ENGINEERING RESEARCH UNIT

Researchers in the Engineering Research Unit conduct investigations to (1) minimize fuel energy required for grain drying, (2) measure and control dust from grain handling, (3) reduce damage to grain from handling, and (4) develop an understanding of solids mixing. Recent progress in these areas of research is summarized as follows.

Minimizing Fuel Energy Required for Grain Drying

We found that desiccant-dehumidified air substantially decreased drying time for corn and milo. Energy savings over natural air drying were small due to the electrical fan energy used to dry the desiccant and restore the drying potential of the silica gel. However, mold growth decreased when desiccant dried air was used. Susceptibility to corn breakage was unaffected by use of desiccant.

A desiccant is an efficient energy storage media. We found that more than 85 percent of the original drying potential could be maintained in silica gel after storing 87 days. Using a solar regenerated desiccant for drying corn and milo during periods of high humidity was technically feasible and in

some cases energy efficient. The largest single cost item in the drying system was the silica gel. The probability of silica gel becoming more abundant and less expensive is small; however, less expensive desiccants could be used. Developing a solar energy storage system using a calcium chloride solution may be appropriate in grain drying.

Air flow rate was the most important factor in designing and operating in-bin grain drying systems. Adding solar heat did not change airflow requirements. However, drying time was more predictable and energy requirements were less when solar heat was added. Solar collector systems used with in-bin grain drying were more effective during cool and cold weather than during hot weather.

We studied the performance and cost of eight experimental on-farm solar collectors. Solar grain drying costs were compared with costs of owning and operating conventional grain dryers. The costs of the least expensive collectors were as low or lower than those of some conventional grain dryers. Depreciation and fuel costs were major cost items. Fixed costs for the eight solar collectors ranged from 6.6 to 26.6 cents/bu; variable costs ranged from 1.5 to 8.4 cents/bu. Further research, mass production, and increasing energy costs should enhance the economic possibility of solar grain drying. However, its dependance on sunshine and the uncertainty of solar performance during inclement weather may limit its use to a "solar grain drying belt."

A combination solar collector and rock-heat storage unit was effective in using solar energy, increasing the drying potential and ambient air, and reducing the amount of electric energy input needed for drying. Depending upon the drying date, batch in-bin drying of wet grain attained a reduction of about 10 percentage points in moisture content during 10 days of fair, sunny weather. The combination solar collector and rock heat-storage unit increased the number of hours that solar heat was available to warm the ambient air. We found that drying efficiency was greatest during cold, wet-weather, test periods.

Comprehensive Simulation Study of Corn Production and Low-Temperature Corn Drying

Modeling of corn production and low-temperature drying have suggested management strategies and design recommendations that can improve productivity or reduce the energy dependence, or both, of corn drying. Planting strategy and hybrid selection are the key management variables to maximize production. Harvest rate and beginning harvest moisture are the key management variables that affect the success of natural air drying and the energy requirements. The energy efficiency of low-temperature drying can be improved by the design and use of higher efficiency fans. This provides more ambient air with moisture absorbing capacity per unit of electricity used. The optimum grain moisture content to begin harvest is 24 percent (wet basis). For harvesting systems with low capacity, the optimum moisture increases to 26 percent (wet basis), whereas a high capacity harvesting system could begin harvest at 22 percent moisture (wet basis). Using controlled filling, bins with a grain depth of 5 to 6 m and a fan power to grain ratio of 1 to 1.5 kW/21.5 tons of corn can be filled in 2 to 3 weeks and dried with about 1,000 hr of fan operation. A farmer with natural air drying bins for his entire crop can expect to harvest 5 to 8 percent of his crop every day without exceeding the system's capacity. Harvest can begin with a corn moisture of 26 percent (wet basis).

Measuring and Controlling Dust from Grain Handling

The Engineering Research Unit continues its major effort in response to the challenge of alleviating the problem of dust explosions and related problems on handling, control, and utilization of grain dust. Controlling grain dust emission is badly needed. Any source of dust, however insignificant, should be reduced or eliminated to be consistent with goals to improve, protect, and preserve air quality and industrial safety. However, effective control measures for dust have yet to be established.

For nearly a century, scientists believed that if a satisfactory dust collecting system could be devised, the danger of dust explosions and health hazards would be eliminated. Consequently, much effort has been concentrated on separating dust from dust-laden air by bag filters, electronic precipitators, and cyclone collectors. Separating dust from dust-laden air can be effective, however, installation, operation, and maintenance costs can be expensive. Moreover, all current methods of removing dust from dusty air require much energy. Another way to prevent a dusty environment is to prevent dust from forming. Preventing dust forma-

tion can be divided into two broad categories: (1) applying chemical additives to grain to prevent dust formation during handling, and (2) using mechanical devices that reduce dust formation during handling.

In studying the application of edible oil to grain to reduce dust, we treated wheat and corn with 0.04 percent soybean oil and 0.02 and 0.06 percent mineral oil, each with and without malathion, to reduce grain dust emission during handling and to preserve quality of the grain in storage. A sample without additives served as a control. After applying the additives to grain, the samples were conveyed immediately in a small elevator leg, and the amount of dust generated was measured. The grain was stored at ambient temperature (15° to 25°C) for 1, 3, 6, and 12 months and the dustiness measured. Dust generated during grain handling was drastically reduced by as little as 0.02 percent added oil. However, the effect diminished sharply after 6 months of storage. Applying malathion with soybean oil or mineral oil did not affect the biological effectiveness or persistence of malathion on treated wheat or corn. Wheat samples were milled and baked after 1, 3, 6, and 12 months of storage. There was no effect on milling or baking quality. Rancidity, as measured by free fatty acids and peroxide value, was not a problem.

We tested a grain nozzle manufactured by American Technical Systems, Memphis, Tenn., for its performance and practicality in reducing grain dust emission during grain handling. The device was constructed of polyurethane, and the only moving part was an impeller rotating at 60 to 80 rpm, as a result of grain entering the nozzle. The centrifugal action drove the grain to the outside dimension of the nozzle, while dust and fine material were concentrated in the center. The compacting action of the exit metering gate produced laminar flow of the grain leaving the nozzle with little emission of dust. Wheat and corn each at high (2,800 bu/hr) and low (1,400 bu/hr) flow rates were transferred with and without the grain nozzle into a steel grain bin. We measured dust concentrations by a high volume air sampler and by obscuring an infrared light beam. Particle size distribution was measured inside the grain bin *in situ*. A comparison of dust emission rates for grain moved with and without a grain nozzle showed that the grain nozzle markedly reduced dust emission inside the grain bin.

Regulations restricting dust emissions from grain elevators have forced operators to improve dust control. Returning large quantities of collected dust to grain merely passes the disposal problem on to the next grain handler. We discourage this practice. A possible solution is to treat grain dust as a byproduct and to use it as a fuel or as a soil conditioner or organic fertilizer, or both, after composting. Assuming the grain is handled once (10 billion bu/yr), and that it generates on the average of 0.05 percent dust, the total amount of available dust, if it were all collected, would amount to 150,000 tons.

Grain dust could be useful as a fuel. Its heat value is about 16.2 MJ/kg (7,000 Btu/lb). At 70 percent conversion efficiency, 1 kg of grain dust could produce 11.3 MJ of energy. However, to utilize dust, it is necessary to develop a new method of burning to extract maximum heat and avoid pollution. To accomplish this, a small furnace with a fuel capacity of 13.6 kg/hr (30 lb/hr) of grain dust was designed, constructed, and tested at the U.S. Grain Marketing Research Laboratory (USGMRL). A gas burner was used only at start-up. Furnace efficiency ranged from 15 to 30 percent for heat generated at 7.3 to 13.2 kW (25,000 to 45,000 Btu/hr). An improved design of the furnace was constructed with an efficiency of 70 percent.

Composting grain dusts at moisture contents of 55 percent (wet basis) was accomplished in a cylindrical, continuous composter (diameter 0.55 m by 2.6 m long) which provided aeration and mixing. About 2 weeks was required during which time aerobic decomposition took place at temperatures as high as 65°C. Output was about 5 kg of compost/day at moisture contents between 65 and 75 percent. Weight losses during composting were 25 to 45 percent. The compost contained 2.5 percent nitrogen, 0.5 percent phosphorus, and 1.7 percent potassium. Acceptability of grain dust compost as a soil conditioner or fertilizer, or both, was evaluated with tomato plants.

Wheat and corn dusts collected in typical grain handling facilities were characterized chemically for composition and physically for size, shape, surface characteristics, and agglomeration tendencies. Protein content increased with decreased particle size. Scanning electron micrographs revealed that fine dust particles of wheat and corn, except for trichomes in wheat dust, were spherical.

We measured thermal conductivity and specific heat of wheat, grain sorghum, and corn dusts at ambient temperature. The moisture contents of

the dust samples ranged from 8.8 to 17 percent (wet basis) and the densities varied between 240 and 580 kg/m^3. Under these conditions, thermal conductivity values ranged from 0.062 to 0.074 W/m-°C for wheat dust, 0.08 to 0.092 W/m-°C for grain sorghum dust, and 0.086 to 0.101 W/m-°C for corn dust. Specific heats ranged from 1,900 to 2,200 J/kg-°C for all three types of dusts. Thermal conductivity of dust increased linearly with moisture content and density; specific heat of dust increased linearly with moisture content.

We determined equilibrium moisture content in wheat, corn, sorghum, and soybean grain and in dusts produced during handling of these grains in marketing channels. The equilibrium moisture content of each type of dust was close to that of the parent grain. Corn dust absorbed more moisture at lower relative humidity (<50 percent) than at higher relative humidity; for sorghum grain and soybean dusts, the relation was reversed. These differences may be related to differences in content and distribution of oils and waxes in the kernels of various types of grains.

The amino acid composition of grain and grain dust for wheat, corn, sorghum, soybean, wheat-corn mixture, and rice was determined by an automated ion-exchange analyzer. Protein content was about 1 to 2 percent (dry basis) less in the dust than in the corresponding grain, except for soybeans. The protein content of soybean dust was only 13 percent compared to about 41 percent in the soybean. The essential and limiting amino acids, lysine and threonine, were higher in protein of wheat dust than in the protein of wheat; glutamic acid and proline were higher in wheat protein than in wheat dust protein; there was a similar trend for corn. Proteins of all dust samples contained less leucine than proteins of the grains. Glutamic acid, proline, and isoleucine contents in sorghum dust were about one-half those in sorghum grain protein. Only glutamic acid content was lower in soybean dust than in soybean protein. Arginine, glutamic acid, methionine, and tyrosine were lower in rice dust protein than in rice protein. The amino acid composition in the proteins of grain dusts depended on the structure and composition of the grain, the part of the kernel from which the dust was obtained, and the relative composition of amino acids in the respective grains.

A number of standard tests have been developed to measure dust explosibility and flammability. These tests have been useful in ranking the relative hazards of various types of dust but do not provide sufficient information to construct realistic models of dust explosion phenomena or to evaluate explosive hazards under field conditions. In our dust explosion studies, we have chosen several standard tests and have modified the apparatus to allow us to obtain data that will be useful in modeling studies and for scaling to field conditions. These modifications define the experimental conditions more precisely but do not compromise the basic nature of the tests so that comparisons can be made between newly-obtained data and the large body of standard test results available in the literature.

We reviewed the literature related to engineering aspects of grain dust explosions up to 1978. The review included dust cloud composition and generation, grain dust generation during grain handling, grain dust evolution from a grain mass into air, dust entrainment from a dust layer to an air stream, and dust settling from a moving or stagnant cloud. The review also covered dust combustion without explosion, dust explosibility, theoretical analysis of a dust explosion, flammability of mixtures of vapors, gases, and dust clouds, dust cloud detonability, methods of preventing rapid exothermic chemical reactions, and methods of preventing damaging over-pressures.

An international symposium, Grain Dust—Its Characteristics, Explosibility, Hazard Control, and Utilization, was organized by USGMRL personnel and held on October 2 to 4 at Manhattan, Kans. The purpose of the symposium was to discuss recent research and technology on grain dust. It covered physical and chemical characteristics, explosibility, utilization, risk analysis, monitoring dust concentration in the atmosphere, and elevator and machinery construction to minimize explosion hazards. Research papers were presented by researchers from Australia, England, Japan, Poland, Switzerland, and the United States. In addition, there were reports from five committees working on various phases of grain dust research and representing the National Grain and Feed Association, American Society for Testing and Materials, American Society of Agricultural Engineers, and the National Institute for Occupation Safety and Health. Of the 42 technical presentations, 11 were from the U.S. Government, 12 from universities, 10 from industry, and 9 from other research organizations. A total of 577 people attended, representing 33 states in the United States and 19 countries.

Reducing Damage to Grain from Handling

We constructed and tested a number of grain spreaders. Using mechanical grain spreaders to fill bins with dry shelled corn significantly improved the uniformity of distribution of fine and broken material and reduced breakage when the speed of the moving grain was reduced. Currently, we are conducting tests on an improved design grain spreader to determine its effect on reducing grain breakage.

Developing and Understanding of Solids Mixing

Mixing or blending operations are carried out on particulate solids in chemical, metallurgical, pharmaceutical, and grain industries. Despite its obvious importance, mixing of solids is far from completely understood. Therefore, there is need for fundamental work to delineate the mixing process and to characterize resulting mixtures on the basis of fundamental theory.

Characterizing solids mixtures is an important aspect in solids mixing. We tested the feasibility of the Discrete Fourier Transform (DFT) for characterizing both random and ordered solids mixtures. DFT power spectrum possesses more significant physical meaning than variance itself. Computer simulated results showed that the maximum component of the DFT power spectrum could be employed as a mixing index, and this index could distinguish random from ordered mixtures. For mixing processes obeying the Fickian diffusion equation, a linear relationship exists between the logarithmic plot of the variance and the maximum DFT power spectrum component.

GRAIN QUALITY CHARACTERIZATION RESEARCH UNIT

Work of the Grain Quality Characterization Research Unit concerns developing and evaluating chemical, biochemical, physical, and physicochemical methods, and developing instruments for characterizing and determining the quality of cereal grains. The information from these investigations is used to develop methods for evaluating cereal grains in marketing channels and developing, in cooperation with the Agricultural Marketing Service and the Federal Grain Inspection Service, proposals for modifying and improved grain standards and grades. Specifically, researchers conduct basic and applied research on (1) the value and limits of objective tests in the present grain standards and methods to simplify, accelerate, and automate those objective tests; (2) methods to replace subjective evaluation in present grain standards by objective, simple, rapid, and automated assays; (3) methods that are not included in the present grain standards but which are needed to fully determine grain quality; (4) physical properties and composition of cereal grains; and (5) developing and standardizing procedures appropriate for evaluating grain in laboratory and marketing channels. Recent progress in these research areas is summarized as follows.

Identifying Class and Variety of Wheat

We need simple objective methods that will permit assigning class(es) for unknown wheat samples. A color test employing sodium hydroxide has been used by geneticists for a number of years to identify red wheat varieties. The procedure was investigated as one which might be useful in marketing channels for distinguishing red varieties from white, club, and durum wheats. We modified the procedure to one that required only 5 minutes and could be performed on a single kernel. An untrained observer could correctly classify as red or non-red all of the 87 wheat samples examined, which represent 60 American varieties, including all classes. Yellow berry kernels from a sample of hard red winter wheat presented no difficulty.

We measured polyphenol oxidase activity as a possible method for identifying wheat varieties or classes. We also developed a simple, rapid procedure employing a Clark type polarographic electrode for determining enzyme activity in wheat with conditions (pH, temperature, etc.) determined for measuring activity toward a variety of substrates. Substrates investigated included phenol, L-tyrosine, catechol, caffeic acid, L-dopa, dopamine, gallic acid, pyrogallol, and d-catechin. We studied 30 wheat varieties, including hard red winter, soft red winter, hard red spring, white, club, and durum wheats. Different samples of the same variety gave comparable activities toward all substrates, even from different growing locations or crop years. The durum wheats had lower activities than varieties from the other classes. Differences in activities toward specific substrates were noted between classes and among varieties in the same class.

Standard Method for Measuring Susceptibility of Corn and Soybeans to Breakage During Handling

The importance of corn and soybeans in world trade in general and for U.S. balance of payments in particular is well known. Measuring and maintaining corn and soybean quality, therefore, are of concern, and methods to measure their breakage susceptibility during harvesting and handling should be evaluated. A model CK-2 Stein breakage tester employing a standard procedure was used to measure breakage susceptibilities of corn and soybeans. Results correlated highly with those from a grain accelerator that simulates operations of a grain elevator. Breakage increased as temperature or moisture content decreased. Corn samples assigned grade No. 2 differed widely in breakage susceptibility; furthermore, corn samples with similar breakage susceptibility graded No. 1 to No. 4. Breakage susceptibility for 50 percent of 61 commercial soybean samples exceeded 12 percent. Official grading does not indicate susceptibility of grain to breakage. An objective method to measure the susceptibility of both corn and soybeans to breakage would be useful.

Evaluating Hard White Winter Wheat Bran

In human food, bran from white wheat is preferred because it is light colored and possibly milder in taste than bran from other classes of wheat. The recent development of hard white winter wheat breeding lines by Kansas State University has raised a question regarding the use of those brans for human food. Limited testing indicates that the bran from hard white winter wheat could be suitable as a human food; larger scale tests by food companies appear to be warranted when sufficient hard white winter wheat is available.

GRAIN QUALITY AND END-USE PROPERTIES UNIT

Research activities in the Grain Quality and End-Use Properties Unit are concerned with (1) identifying physical and structural characteristics and chemical components that govern or are associated with functional properties; (2) developing, improving, and evaluating methods and instruments that can be used to objectively, rapidly, and accurately characterize and evaluate grain in domestic and export marketing channels; and (3) cooperating with plant breeders throughout the Great Plains and with agronomists, plant physiologists, entomologists, and biochemists at Kansas State University by providing milling, baking, and biochemical expertise and support for selective projects of mutual interest. Specifically, researchers

(a) Determine and evaluate the functional (milling and breadmaking) properties of early generation and potentially new hard winter wheats bred for the Great Plains and evaluate the earliest feasible generation of hard winter wheats bred for genetically high-protein content. Kjeldahl (protein) analytical equipment and the 10-g mixograph, together with micro- and macro-milling and breadmaking equipment, are employed to determine functional properties of about 2,500 plant breeders' samples (10 g to 1,500 g).

(b) Develop new methods and techniques of determining chemical, milling, breadmaking, physical-chemical, and biochemical properties of hard wheats.

(c) Develop energy-conserving baking methods and high-protein and nutritionally improved breads.

(d) Develop physical and biochemical fractionating and reconstituting techniques to relate functional (breadmaking) to biochemical properties of wheat-flour components and determine the chemical fractions and components of wheat responsible for quality differences. After literally taking the flours apart, corresponding gluten-protein, gliadin- and glutenin-protein, modified and unmodified, and other wheat-flour fractions of good and poor quality wheat flours are interchanged, one at a time and in combinations, in the reconstituted flours. Fractions and reconstituted flours are characterized by physical, biochemical, and breadmaking techniques.

Research during the past year has been in the following areas.

Determining and Evaluating Functional Properties of Potentially New Hard Winter Wheats

About 470 samples, each about 1,500 g, of agronomically promising new varieties and recent releases of hard winter wheat were characterized and evaluated in terms of their functional properties including wheat hardness; bolting properties and flour yield; flour ash; dough mixing, oxidation, and water requirements; bread crumb grain and color scores; and loaf-volume potential. About 29

percent of the samples had good milling, chemical, breadmaking, and physical-dough properties. Leading commercial wheat varieties of tomorrow are among them, and a number of progenies, in addition, had genetically high protein contents.

We screened about 500 samples (8 g) of the earliest generation crosses, bred in Kansas for genetically higher protein content than those of the present commercially grown varieties of wheat. About 358 progenies contained 1 to 3.5 percentage points, and 37 contained 2.5 to 3.5 percentage points more protein than their controls.

About 775 small samples (40 to 100 g) of early generation progenies of hard winter wheats were micro-milled and evaluated for milling. Each sample of flour was subjected to certain analytical, water-absorption, and mixogram tests. About 290 (37.5 percent) had promising overall functional properties. Also, 206 of the 290 promising ones had 1 to 3.8 percentage points, and 27 had 2.5 to 3.8 percentage points more flour protein than their controls.

From 1975-79, average wheat yield in Kansas (31.1 bu) was 6.9 bu greater, and average wheat protein content (11.9 percent) was 0.2 percent higher than the corresponding averages for the 1960's. Thus, the gradual decline in wheat protein content apparently has been halted and reversed during the past 5 years by high protein Eagle and other relatively new Kansas varieties of hard winter wheat. Additionally, during the last 3 years of the 70's (1977 to 1979), average wheat yield in Kansas (32.2 bu) was 8.0 bu greater and average wheat protein content (12.2 percent) was 0.5 percent higher than the corresponding averages for the 60's.

Liquid Chromatographic Analysis of an Estrogen, Coumestrol, in Germinated Soybeans and Flours Therefrom

The Chinese have sprouted beans for over 2,000 years to increase food value and storage time and to decrease objectionable organoleptic properties. Recently, germinated soy flours have been used to increase the protein content and essential amino acids in bread. When soybeans sprout, however, the estrogen, coumestrol, is produced. Both deleterious and beneficial biologic effects of coumestrol have been reported. Thus, it is desirable to establish the location and concentration of coumestrol in germinated and ungerminated soybeans.

Coumestrol content of three germinated and ungerminated varieties of soybeans and their fractions was analytically determined by high performance liquid chromatography. Coumestrol content of soybeans and their fractions increased with increasing germination time. The hulls, 11 to 15 percent of the bean, contained more than twice as much coumestrol as that of the endosperm plus germ (78 to 85 percent of the bean). The sprouts contained a relatively small amount of the total coumestrol, and coumestrol content of the whole bean and its fractions varied with variety.

Note on an Improved Method of Extracting and Quantitating Coumestrol from Soybeans

Coumestrol, an estrogenic compound, has been found in many forage plants and vegetables; levels were highest in sprouted alfalfa and soybean seeds. Because of increased use of soybean products to enhance protein and lysine contents of wheat products and meat substitutes, researchers in this laboratory modified published procedures to extract the coumestrol from soybeans. High performance liquid chromatography (HPLC) was used to detect coumestrol at the ppm level. Since then, we have developed an improved method for extracting coumestrol from soybeans by considering the effect of the lipid fraction on extraction and the type of solvent on recovery. Coumestrol was then quantitated by HPLC.

Method for Determining Hexosamines in Chitin by Ion-Exchange Chromatography

We developed an ion-exchange chromatography method to determine glucosamine and galactosamine from fungal chitin following acid hydrolysis. The method was designed to handle a relatively large sample size and to minimize the volume of extracts that needed to be evaporated. Final extracts were analyzed on an automatic amino acid analyzer programmed to alternate injections among two columns. Analysis time on the analyzer was 30 min/injection.

Wheat Proteins: What They Do

Wheat is too often regarded as merely a starch food crop, but it contains other valuable nutrients, notably proteins, lipids, minerals, and vitamins. The prominence of wheat is attributed not only to its nutritive value but also to its unique proteins. Unlike any other plant-derived food, wheat contains gluten protein, which enables a leavened dough to rise by forming a structure of minute

cells that retain carbon dioxide produced during fermentation.

To show what wheat proteins do, we related their quality and quantity to important functional (breadmaking) properties that include flour protein content, mixing requirement and tolerance, dough handling characteristics, water and oxidation requirements, loaf volume potential, and bread crumb grain.

Functional (Breadmaking) Properties of Wheat Protein Fractions Obtained by Ultracentrifugation

Good and poor quality bread wheat flours were fractionated into their gluten and starch plus water-soluble fractions. Ultracentrifuging the acid soluble gluten protein (ASGP) at 100,000 g yielded a centrifugate or pellet of high molecular weight (mol. wt.) glutenin proteins (15 percent of ASGP). Ultracentrifuging the decanted supernatant (85 percent of ASGP) at 435,000 g yielded a gel of low mol. wt. glutenin proteins (33 percent of ASGP), a viscous layer of gliadin-like proteins (18 percent of ASGP), and a supernatant of gliadin proteins (34 percent of ASGP). Interchanging the low mol. wt. glutenins or gel fraction of the good and poor quality flours in reconstituted doughs demonstrated that the glutenin proteins control mixing requirement and the gliadin proteins (the viscous layer plus supernatant fractions) control loaf volume and crumb grain. The low mol. wt. glutenins, increased in reconstituted doughs by amounts equivalent to the deleted high mol. wt. glutenins, apparently are superior to the high mol. wt. pellet glutenins.

Physical and Biochemical Properties of Wheat Protein Fractions Obtained by Ultracentrifugation

The above ASGP fractions and their amounts reconstituted in bread doughs were systematically determined by sedimentation rate studies so that the ratio of amounts of pellet + gel and viscous layer + supernatant proteins were about 50:50. For the poor quality variety, high mol. wt. pellet proteins sedimented in only 35 min at 100,000 g and low mol. wt. gel glutenins in 6 hr at 435,000 g. For the good quality variety, however, 2 hr was required to sediment the high mol. wt. pellet glutenins and 9.25 hr to sediment the low mol. wt. gel glutenins. Thus, the first half of the protein to sediment, corresponding to classical glutenin, differed greatly for the poor and good quality flours. The slowly sedimenting half of the acid soluble gluten proteins (gliadins) of the good and poor quality flours sedimented at about the same rate. The good and poor quality gluten protein fractions were characterized by starch gel and sodium dodecyl sulfate polyacrylamide gel electrophoresis. The polyacrylamide gels indicated large differences in the molecular size of proteins in the fractions within each flour. Also, for protein fraction of the good quality flour, there were protein bands that were not present in the corresponding fractions of the poor quality flour, and vice versa.

Defatted and Reconstituted Wheat Flours. Response to Shortening of Flour Differentially Defatted by Solvents at Various Temperatures

Lipids, a minor wheat flour component, play a major role in the positive loaf volume and crumb grain response of bread to shortening. The response is related to quantities and types of lipids. Increased mixing time of the defatted flours depended mainly on the quantity and the types of lipids in the flour. Shortening had a detrimental effect on loaf volume and crumb grain in the absence of native flour lipids, and the detrimental effects were linearly related to the amount of polar lipids removed from the defatted flour. In flour containing no nonpolar lipids, loaf volume was governed by the quantity of polar lipids, shortening, and interaction of shortening and polar lipids.

Defatted and Reconstituted Wheat Flours. Response to Shortening Addition and Lipid Removal in Flours that Vary in Breadmaking Quality

Lipid removal increased mixing time; the increase was greater for 2-propanol than for Skellysolve B extraction. Removing lipids affected mixing time substantially more than did addition of 3 percent shortening. Small differences in amounts of free polar lipids in flours that vary in breadmaking quality accentuated differences in "loaf volume (LV) potential" of flours through the interaction of free polar lipids and shortening: the better the inherent quality of a flour, the greater the benefits derived from adding shortening. The improving effects on LV of bread baked without shortening from flours defatted by 2-propanol apparenly resulted from removing most of the bound polar lipids. The magnitude of the effects was related to

the inherent quality of flours, likely due to differences in their protein quality and their protein-protein interactions. We concluded that good LV and crumb grain can be obtained from good protein quality flours in which adequate protein aggregation is enhanced by free polar lipids that can interact with proteins and shortening. To bring out the maximum LV potential of flours, the multiple interaction of PROTEIN-LIPID (FREE POLAR)-PROTEIN in the presence of shortening seems to be superior to the mere formation of protein-protein aggregates.

Wheat Flour Lipids in Breadmaking

A review on the role of wheat flour lipids provides an updated discussion of factors, including new information, affecting the functional (breadmaking) properties of defatted and reconstituted wheat flour; lipid binding during wetting or dough mixing; lipid oxidation during dough mixing; interaction between lipids and starch granules; and functional properties of flour lipids in breadmaking. The review also discusses models proposed by several scientists on interaction of lipids with wheat flour, dough, and bread macromolecules.

ECONOMICS, STATISTICS, AND COOPERATIVES SERVICE,[1] NATIONAL ECONOMICS DIVISION

Research activity of this unit encompasses the economic evaluation of a wide variety of subjects related to producing and marketing grain and grain products. General research areas include grain quality, production costs, storage, and marketing and transportation analysis. Special areas of research include assessing such current issues as dust emission, solar grain drying, and analyzing data used in making public policy decisions.

Main objectives of these economic evaluations are (1) to provide economic assessments of new technologies and approaches to grain production and marketing such as comparing costs of solar and conventional grain drying systems and estimating costs of pelletizing grain dusts; (2) to analyze the efficiency of assembling, processing, and distributing grain and grain products; (3) to conduct supply-demand analyses; (4) to estimate costs of producing and marketing grains and grain products, including white pan bread; and (5) to provide quick analyses of current topics.

Basic to the research efforts of this group, headquartered in Washington, D.C., is the interdisciplinary approach and environment afforded by the U.S. Grain Marketing Research Laboratory. This unit works in close cooperation with USDA's Science and Education Administration-Agricultural Research personnel, as well as with personnel at Kansas State University.

VISITORS TO THE U.S. GRAIN MARKETING RESEARCH LABORATORY

Many hundreds of visitors to the U.S. Grain Marketing Research Laboratory came from 38 states of the United States and 49 countries throughout the world. It is impossible in the short space available to list all the distinguished visitors.

We would like, therefore, to acknowledge here major groups that came at the invitation of several sponsoring organizations. The Kansas Wheat Commission, in cooperation with Great Plains, Inc.; Wheat Associates Inc.; and USDA's Foreign Agricultural Service sponsored wheat teams from Egypt, Indonesia, Japan, Jordan, Malaysia, Mexico, Morocco, Philippines, Singapore, and Thailand. Participants in two milling short courses organized by Kansas State University were from Bolivia, Canada, Chile, Colombia, Dominican Republic, Ecuador, El Salvador, England, Guatemala, Honduras, Jamaica, Mexico, Peru, Venezuela, and the United States.

We organized a tour for and lectured to participants from Costa Rica, Ethiopia, Korea, Philippines, Taiwan, Tanzania, Upper Volta, and Yemen in a Grain Storage and Marketing Short Course. We were

[1] Formerly the Economic Research Service.

visited by large groups of farmers from Australia, Great Britain, and the United States.

Several large groups of participants in short courses organized by the American Institute of Baking visited our facilities. Kansas State University sponsored tours of classes in agronomy, biology, biochemistry, crop science, and agricultural engineering.

And last, but certainly not least, we were visited by many groups representing the general public, clubs, schools, colleges, and companies. The frequent and, to the best of our knowledge, only complaint we received was in the form of a regret that not enough time was scheduled for a more thorough and detailed visit.

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——— May 16, 1979. Molecular approach to breadmaking —an update and new perspectives. Plenary lecture, acceptance of the M. P. Neumann medal, Detmold, Germany.

——— June 4, 1979. Flour supplementation. Association of Operative Millers-Kansas State University short course, Manhattan.

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——— June 7, 1979. (a) Research on grain dust control, (b) New approaches to testing grain in marketing channels, and (c) Life and agriculture in the PRC. 25th anniversary conference, National Association of Chief Grain Inspectors and Federal Grain Inspection Service, Denver, Colo.

——— June 8, 1979. Structure of cereal grains as related to end-use properties. Short course, Cereals: Their Structure and Chemistry, American Association of Cereal Chemists, Kansas State University, Manhattan.

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——— August 14, 1979. Wheat flour components in breadmaking. International Conference for Food and Beverages: Recent Progress in Cereal Chemistry and Technology, Copenhagen, Denmark.

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——— August 27-31, 1979. Director, Wheat Chemistry and Technology Seminar: (a) Biochemistry of breadmaking, (b) Molecular approach to breadmaking, (c) Quality control, and (d) Storage of wheat and milled wheat products, American Association of Cereal Chemists-Japan Wheat Flour Millers Association, University of Tokyo, Japan.

——— September 2-11, 1979. Guest lecturer, Seoul National University, Korea.

I. Korea Institute of Science and Technology
   (a) Starch-lipid-protein interactions in cereal systems
   (b) Food-analysis; theory and practice
II. Korea Flour Millers Industrial Association
   (a) Composition and functionality of wheat flour components in breadmaking
   (b) Wheat flour supplementation
III. Seoul National University, College of Agriculture, Suweon
   (a) Structure of cereal grains as related to end-use properties
   (b) High protein food from cereals
   (c) Agriculture in the People's Republic of China
IV. Office of Rural Development Research activities of the U.S. Grain Marketing Research Laboratory

Quinlan, J. K. March 29, 1979. Laboratory testing of candidate grain protectants. North Central Branch, Entomological Society of America, Indianapolis, Ind.

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Schnake, L. D. March 7, 1979. Economics of handling grain dust: a progress report. National Grain and Feed Association Annual Convention, Las Vegas, Nev.

Seitz, L. M. March 1, 1979. A simple assay for measuring extent of fungal invasion (weathering) in sorghum grain. 11th Biennial Grain Sorghum Research and Utilization Conference, Wichita, Kans.

Shethna, Y. I., Bulla, L. A., Jr., Kramer, K. J., and Davidson, L. I. March 16, 1979. Studies on the proteinaceous

crystalline inclusion of *Bacillus thuringiensis* subsp. Kurstaki. Annual meeting, Missouri Valley Branch, American Society for Microbiology, Omaha, Nebr.

Storey, C. L. November 13, 1979. Insect losses and problems in U.S. grain exports. Fumigation symposium, University of Wisconsin, Madison.

——— February 14, 1979. Negotiations for phosphine fumigation of U.S. hay exports to Japan. Technical meeting with Japanese Ministry of Agriculture, Fisheries and Forestry, Plant Quarantine Division and Feed Safety Division, Tokyo, Japan.

——— Sauer, D. B. September 27, 1979. Report on insect and microbial survey of U.S. wheat and corn exports. U.S. Department of Agriculture, Federal Grain Inspection Service, Standardization Division, Kansas City, Mo.

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——— Bulla, L. A., Jr., and Consigli, R. A. May 11, 1979. Molecular biology of the granulosis virus of *Plodia interpunctella*. U.S.-Japan Intersociety Microbiology Congress, Honolulu, Hawaii.

——— Bulla, L. A., Jr., and Consigli, R. A. May 7, 1979. Characterization of an extremely basic protein derived from granulosis virus nucleocapsids. 79th annual meeting, American Society for Microbiology, Los Angeles, Calif.

Tweeten, T. N., Wetzel, D. L., and Chung, O. K. May 1, 1979. High performance liquid chromatography of glycolipids from wheat flour polar lipid fractions: determination and physico-chemical characterization. Joint meeting American Oil Chemists' Society and Japan Oil Chemists' Society, San Francisco, Calif.

Tyrell, D. J., and Bulla, L. A., Jr. March 3, 1979. Proteinaceous mosquito toxin of *Bacillus thuringiensis*. Fifth annual mini-meeting, Division of Biology, Kansas State University, Manhattan.

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SEMINARS PRESENTED AT THE U.S. GRAIN MARKETING RESEARCH LABORATORY

Beeman, R. W. September 7, 1979. Mode of action of foramidine insecticides. Pesticide Research Center, Michigan State University, East Lansing.

Benezet, H. J. September 13, 1979. Thidiazuron absorption, distribution, and metabolism by bluegills. Department of Entomology, University of Missouri, Columbia.

Bushuk, W. March 20, 1979. Variety identification by gliadin electrophoresis. University of Manitoba, Canada.

Converse, H. H. February 7, 1979. Solar grain drying. U.S. Grain Marketing Research Laboratory, Manhattan, Kans.

Edelman, J. March 30, 1979. Food research activities at The Lord Rank Research Centre. The Lord Rank Research Center, London, England.

Finney, K. F. May 2, 1979. Bread wheat proteins: their quality and what they do. Research leader, Grain Quality and End-Use Properties Unit, U.S. Grain Marketing Research Laboratory, Manhattan, Kans.

Garcia-Olmeda, F. June 14, 1979. Purothionins. Departmento de Bioquimica, E.T.S. Ingenieros Agronomos, Madrid, Spain.

Graveland, A. April 5, 1979. Wheat flour proteins and baking quality. Institute for Cereals, Flour & Bread, TNO, Wageningen, The Netherlands.

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McGaughey, W. H. March 7, 1979. Developing *Bacillus thuringiensis* as a stored grain insecticide. U.S. Grain Marketing Research Laboratory, Manhattan, Kans.

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Pedersen, J. R. April 18, 1979. Technical assistance in grain storage, processing and marketing, and agri-business development under the KSU/AID contract. Department of Grain Science & Industry, Kansas State University, Manhattan.

Reeves, R. January 24, 1979. Lipid metabolism and cardiovascular disease. Department of Foods & Nutrition, Kansas State University, Manhattan.

Taylor, T. A. April 16, 1979. Stored-product entomology in Nigeria. Institute Agricultural Research & Training, Ibadan, Nigeria.

Yu, S. S. J. August 27, 1979. Toxicological significance of microsomal mono-oxygenases in insects. Department of Entomology, Oregon State University, Corvallis.

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*Tresa D. Jones ....Research assistant
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Dr. L. D. Schnake ....Agricultural economist
Margie L. Burk ....Clerk-typist

Maintenance Staff

Chester D. Litle ....Air conditioning mechanic-foreman
Robert L. Welfringer ....Air conditioning mechanic
Terry B. Cassity ....Electrician
Donald D. Brill ....Custodian
Kerwin K. Crabs ....Maintenance worker
Lacy Lowery ....Custodian

*In cooperation with the Kansas Agricultural Experiment Station.

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